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Effects of Dietary Microalgae *Schizochytrium* sp. Supplementation on Growth Performance and Skin Color in Jack Dempsey cichlid (*Rocio octofasciata*)

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ABSTRACT

Growth retardation and decreased vivid coloration are significant issues in the ornamental fish market, particularly among cichlids. This study investigates the effects of Schizochytrium sp. microalgae supplementation on the growth and skin coloration of the Jack Dempsey cichlid (*Rocio octofasciata*). Three experimental groups were established: a control group (C) with no supplementation, and two microalgae-supplemented groups with 0.5% (S05) and 1% (S10). The control group was fed a commercial diet, while the S05 and S10 groups received the microalgae mixed with the commercial feed via spraying. A total of 135 Jack Dempsey fish (mean initial weight: 1.17 ± 0.14 g) were stocked into nine glass tanks (100 L each), with three replicates per group. After a 60-day feeding trial, growth indices revealed significant differences ($p<0.05$) between the control and algae-supplemented groups. The S10 group exhibited the highest final weight (FW) and the lowest feed conversion ratio (FCR). Additionally, the weight gain (WG) and specific growth rate (SGR) values for the S10 group were significantly higher than those of both the control and S05 groups ($p<0.05$). However, skin color parameters, including L^* (brightness), a^* (+red/-green axis), b^* (+yellow/-blue axis), chroma (Ch), and hue angle (Hue), showed no statistical differences among the groups. This study demonstrates that a diet supplemented with 1% *Schizochytrium* sp. can enhance growth parameters and serve as a beneficial feed additive for Jack Dempsey cichlids.

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Introduction

Due to the increasing interest in aquarium maintenance, the ornamental fish sector is currently experiencing growing attention (Pezeshk et al., 2019; Sathyaruban et al., 2021). With advancements and heightened interest in the aquarium sector, ornamental fish farming has begun to secure its rightfulplace within aquaculture production (Mutlu, 2019; Qaranjıkı, 2017). This represents a significant economic activity in many developing countries, boasting an annual growth rate of 14% worldwide and a market value of 15 billion US dollars (Lau et al., 2023; Yanar et al., 2019). One of the key factors contributing to the increasing volume of ornamental fish farming and trade is the production and marketing of the most sought-after species. In this context, the balloon variant of Jack Dempsey (*Rocio octofasciata*), with its rounded contours and appealing colours, is a high-value species favored by hobbyists (Sepil et al., 2022). Jack Dempsey inhabits freshwater and benthopelagic regions and is distributed in tropical areas in North and Central America. It is one of the Neotropical cichlids (Mendoza-Palmero et al., 2019). The water quality in which Jack Dempsey lives typically ranges between 22-30°C, and pH 7.0-8.0 (Anonymous, 2024).

Previous studies have demonstrated that proper nutrition in fish is a crucial factor that influences growth, reproduction, and pigmentation (Cavdar et al., 2020; Hekimoğlu & Sönmez, 2023; Pezeshk et al., 2019; Yeşilayer et al., 2020). The primary objective in aquaculture is to ensure optimal development with species-specific high-quality feeds, which are essential for both economic and nutritional quality. Quality feeds maintain fish health during the cultivation process and minimize environmental waste. This objective should be applied not only in edible seafood production but also in ornamental fish farming (Cavdar et al., 2020). In cultivating ornamental fish, the appropriate supply of feed ingredients and additives is essential for their growth, reproduction, and coloration (Şahin et al., 2022). Therefore, research on

ornamental fish diets have concentrated on the use of natural components (Yeşilayer et al., 2011) and additives (Karsli et al., 2018; Yeşilayer et al., 2020; Yiğit et al., 2019) to improve the outcomes of effective aquaculture techniques, taking into account factors like resistance to disease, survival ratio, and coloration and reproduction.

Microalgae have garnered attention in aquaculture due to their potential benefits for fish health and overall industry sustainability, acting as growth promoters, immune stimulants, antioxidants, and sources of disease resistance (Vijayaram et al., 2024). Previous studies have validated their use as a low-level feed supplement (Ghaeni et al., 2011; Khatoon et al., 2010; Komprda et al., 2015; Nunes et al., 2009). Due to their balanced nutritional content, microalgae as a feed or feed additive can potentially replace or reduce the usage of common feed ingredients in aquaculture (Shah et al., 2018). One notable microalga used in aquafeed is *Schizochytrium* sp. (Souza et al., 2020). This microalga is renowned for its high concentration of docosahexaenoic acid (DHA) (Lewis et al., 1999), which is known for its diverse health benefits in both humans and animals. Research has demonstrated that incorporating *Schizochytrium sp.* into the diet can elevate the levels of fatty acids in species such as channel catfish (Li et al., 2009) and, Nile tilapia (Sarker et al., 2016), enhance the final weight of Nile tilapia (Dos Santos et al., 2019), and alter the gut microbiota of rainbow trout (Lyons et al., 2017). Despite the positive effects of incorporating *Schizochytrium* sp. into the diet on the growth performance of various fish species, no information is available regarding the potential effects of supplementing the diet with *Schizochytrium* sp. on Jack Dempsey.

Considering the economic importance of Jack Dempsey in the aquarium industry and the numerous benefits of *Schizochytrium* sp. as a feed supplement, this study was conducted for the first time to evaluate the dietary effect of *Schizochytrium* sp. on growth performance and skin color in Jack Dempsey.

Materials and Methods

Ethical Approval

The study received approval from the Local Ethics Committee of Van Yüzüncü Yıl University (protocol no: 2023/14-13) and was conducted in compliance with standard ethical guidelines.

Experimental Design and Feeding Trial

The research took place at the Aquatic Animals Experiment Unit (SUCAN) within the Faculty of Fisheries at Van Yuzuncu Yıl University, Van, Türkiye. A total of 135 Jack Dempsey (*R. octofasciata*) (mean initial weight: 1.17 ± 0.14 g) were used in this study. The fish was obtained from the SUCAN and the microalgae was supplied from a commercial company (Marinbio, Aydın/Türkiye).

The fish were initially acclimatized for two weeks with a commercial feed (Tetra, Germany) before the trial. Subsequently, they were distributed among 9 glass tanks, each with a volume of 100 L. The fish were divided into three experimental groups: C (control), S05, and S10, with three replicates each. The control group was fed the commercial feed (Table 1), while the S05 and S10 groups were fed the commercial feed supplemented with 0.5% and 1% *Schizochytrium* sp., respectively. Microalgae. was mixed with the commercial feed by spraying (Safari et al., 2022) and stored at +4ºC until use. The fish were fed ad libitum twice a day at 09:00 and 16:00 for 60 days.

The tanks were continuously aerated using a central air pump. Water in the tankss was changed daily by 40-50%, and uneaten food and feces were siphoned out to maintain a clean environment. Throughout the research, a 12-hour light and 12-hour dark photoperiod was applied. Weekly measurements of water quality parameters including dissolved oxygen (6.82 ± 0.13 mg/L), pH (8.29 ± 0.04), and temperature (27.24 ± 0.43°C) were recorded using a multiparameter recorder (AZ Instruments/ AZ86031).

Table 1. Composition of the commercial diet utilized in the investigation.

Ingredient (%)	Quantity
Crude Protein	47.5
Crude fat	6.5
Crude fibre	2
Moisture content	6
Manganese (Mg/kg)	67
Zinc (Mg/kg)	40
Iron (Mg/kg)	26
Vitamin D (IU/kg)	1860

Growth Performance Analysis

All fish were weighed individually at both the start and conclusion of the study. Weight gain (WG), feed conversion ratio (FCR), specific growth rate (SGR), and survival rate (SR) were computed using the following formulas:

WG (g/fish): Final weight (g) − Initial weight (g),

SGR (% / day): (100 × ((*Ln* final fish weight) – (*Ln* initial fish weight)/days))

FCR: Total feed given (g)/Weight gain (g)

SR (%): (Final number of the fish/initial number of fish) × 100.

Color Analysis

Skin color measurements of the fish were conducted using a Konica Minolta CR 400 device, with six different fish per group. In this context, the brightness value (L; -100 black, +100 white), the red-green value (a; -100 green, +100 red), and the yellow-blue value (b; -100 blue, +100 yellow) of the fish in the groups were determined. The skin color parameters *L**, *a**, and *b** were measured from regions near the lateral line and the dorsal part of the fish. Additionally, Hue (H°ab) and chroma (Ch) values were calculated using the a and b values. All measurements were conducted with the Konica Minolta CR 400 device according to the methods specified by CIE (1976).

Statistical Analysis

At the conclusion of the experimental period, data were analyzed using the SPSS 20 for Windows software (SPSS Inc., Chicago, IL, USA). Variance differences between groups were analyzed using one-way ANOVA, followed by the DUNCAN post-hoc test with a significance level of 0.05. The results were presented as mean ± s.d.

Results

Growth Performance

At the conclusion of the 60-day feeding trial (Table 2), the S10 group displayed the highest final weight (FW) and the lowest FCR. Furthermore, the WG, and SGR parameters of the S10 group significantly differed from both the control and S05 groups ($p<0.05$). However, there were no statistically significant differences in growth performance between the control and S05 groups ($p>0.05$). Notably, no mortality occurred among any of the experimental groups during the feeding trial.

Skin Coloration Parameters

At the conclusion of the 60-day feeding trial (Table 3), there were no statistically significant variations among the groups concerning *L**, *a**, *b**, Ch, and Hue values ($p>0.05$).

Discussion and Conclusion

Applying feed additives can be a valuable strategy to achieve efficient and sustainable production in aquaculture (Hoseinifar et al., 2023; Wan et al., 2019). In this context, algae have the potential to reduce reliance on the feed ingredients in aquaculture. The use of microalgae can provide significant benefits due to their ability to enhance growth rates by increasing triglyceride and protein accumulation in the muscles of aquatic species, thus potentially replacing or reducing the use of common feed ingredients (Shah et al., 2018). Additionally, microalgae, due to their inclusion of bioactive compounds, can enhance resistance to diseases, reduce nitrogen release into the environment, and improve omega-3 fatty acid levels, and physiological functions (Idenyi et al., 2022; Vijayaram et al., 2024). This research investigates how the growth performance and skin pigmentation of Jack Dempsey (*R. octofasciata*), a significant species in ornamental fish aquaculture, are affected by varying concentrations of *Schizochytrium* sp. in the feeds.

Enhancing growth performance and improving feed conversion ratio (FCR) in aquarium fish farming are crucial factors for successful production (Hoseinifar et al., 2023). This study demonstrates that growth performance in Jack Dempsey is significantly influenced by the inclusion of 1% *Schizochytrium* sp. in the diet. Parameters such as weight gain (WG) and specific growth rate (SGR) showed a significant increase in fish-fed diets containing S10 group compared to the control group. Additionally, a remarkable improvement in FCR values was observed in the S10 group. Among the doses applied, the addition of 1% *Schizochytrium* sp. showed the most beneficial effect on growth rate, suggesting that a specific dose amount affects growth performance. These improvements in growth performance may stem from bioactive compounds present in algae, such as polysaccharides, fatty acids, pigments, minerals, etc., which make the feed more enticing and encourage consumption (Chen et al., 2021; Idenyi et al., 2022; Li et al., 2023; Siddik et al., 2024; Xie et al., 2019). Moreover, it has been found that *Schizochytrium* sp. is rich in amino acids such as alanine and glycine (Li et al., 2023; Yang et al., 2020), which may enhance food intake and consequently increase the growth rate of the experimental groups. Considering that amino acids stimulate the sense of taste and certain specific amino acids like alanine, glycine, and tryptophan can serve as feeding stimulants (Hu et al., 2020), *Schizochytrium* sp. may have a role in feed attractiveness. In addition, it is well-known that *Schizochytrium* sp., containing high levels of docosahexaenoic acid (DHA), enhances nutrient absorption and metabolic efficiency, supports tissue growth and repair, and has beneficial effects on growth and development in aquatic organisms (Osmond et al., 2021; Raghukumar 2008; Sarker et al., 2016). Although no information is available on the role of *Schizochytrium* sp. as a growth promoter in Jack Dempsey cichlid to date, its effects on growth performance have been investigated in various studies involving different fish species.

Table 2. Effects of dietary *Schizochytrium* sp. on growth performance in Jack Dempsey

	C	S05	S10
IW	1.17 ± 0.01	1.17 ± 0.1	1.17 ± 0.1
FW	5.26 ± 0.10^{b}	5.35 ± 0.14^{b}	5.86 ± 0.08^{a}
WG	4.08 ± 0.09^{b}	4.18 ± 0.14^{b}	4.68 ± 0.09^{a}
SGR	2.49 ± 0.02^{b}	2.53 ± 0.04^{b}	2.68 ± 0.04^{a}
FCR	1.58 ± 0.02^{b}	1.53 ± 0.04^{b}	1.36 ± 0.00^{a}
Survival (%)	100	100	100

Data were shown as means ± SE. Different lowercase letters on each line indicate significant variations between groups ($p < 0.05$). S05, a diet supplemented with 0.5% *Schizochytrium* sp.; S10, a diet supplemented with 1% *Schizochytrium* sp.; WG, weight gain; SGR, specific growth rate; FCR, feed conversion ratio.

Table 3. Effects of dietary *Schizochytrium* sp. on skin coloration parameters in Jack Dempsey

	C	S05	S10
*L**	60.94 ± 1.20	61.94 ± 1.18	61.37 ± 2.70
*a**	-6.22 ± 0.49	-6.02 ± 0.62	-6.11 ± 0.21
*b**	15.01 ± 0.82	14.74 ± 0.84	14.15 ± 0.61
Ch	16.31 ± 0.59	15.96 ± 0.56	15.44 ± 0.52
H°ab	112.63 ± 2.73	112.30 ± 3.21	113.39 ± 1.35

Data were shown as means ± SE. Different lowercase letters on each line indicate significant variations between groups ($p < 0.05$). S05, a diet supplemented with 0.5% *Schizochytrium* sp.; S10, a diet supplemented with 1% *Schizochytrium* sp.; *L**, (+) brightness, (−) darkness; *a**, (+) redness, (−) greenness; *b**, (+) yellowness, (−) blueness; Ch, Chroma; H°ab, Hue.

Similar to our study, Li et al. (2023) reported that supplementation of silver pomfret (*Pampus argenteus*) feeds with 2% *Schizochytrium* sp. positively affected growth performance. Additionally, Dos Santos et al. (2019) reported increased growth performance in Nile tilapia (*Oreochromis niloticus*) juveniles fed with *Schizochytrium* sp. supplemented feeds. In another study, the diet containing *Schizochytrium* sp. (3%) was reported to enhance feed intake and utilization, thereby improving the growth performance of golden pompano (*Trachinotus ovatus*) (Xie et al., 2019). Moreover, Li et al. (2009) claimed that supplementation with 1 and 1.5% dried *Schizochytrium* sp. positively affected the growth performance of channel catfish (*Ictalurus punctatus*). Conversely, Jorge et al. (2022) noted no significant difference in the growth performance of the Nile tilapia (*O. niloticus*) fed diet supplemented with 3% *Schizochytrium* sp. compared to the control group.

One of the key elements influencing ornamental fish prices on the international market is color. (Şahin et al., 2022). Therefore, enhancing the attractive coloration in the aquarium fish industry is considered a significant quality criterion (Sathyaruban et al., 2021). Each color parameter used to determine skin coloration in fish (*L**, *a**, b, Ch, and Hue) represents a specific color characteristic, and the combined evaluation of these parameters provides important information about the fish color (Yeşilayer et al., 2020). Various investigations have shown the beneficial effects of algae on the coloration of ornamental fish. Moreover, there has been no previous research on the effects of *Schizochytrium* sp. on skin coloration in Jack Dempsey. However, in this study, *Schizochytrium* sp. supplementation did not a statistical difference in skin coloration in Jack Dempsey. Although there was no statistical difference, groups fed with algae showed an increase in brightness (*L**) and greenness (*-a**) values. Additionally, the Hue (H°ab) value indicating the relationship between redness and yellowness in the fillet tended to increase in the S10 group. Previous studies also showed the positive effects of adding *Schizochytrium* sp. to the diet on fillet coloration in Atlantic salmon (*Salmo salar*) (Katerina et al., 2020) and Nile tilapia (Jorge et al., 2022). This may be attributed to the high level of micronutrient content in *Schizochytrium sp.*, such as carotenoids like astaxanthin and bioactive compounds (Xie et al., 2019). Furthermore, in our study, among the evaluated concentrations, the addition of 1% *Schizochytrium* sp. showed the most advantageous effect on skin coloration, albeit not statistically significant. This suggests that a specific dosage level may contribute to skin coloration. Therefore, increasing the doses may be the subject of future studies to determine the effect of *Schizochytrium* sp. on skin color. Hence, conducting further studies with different concentrations would be beneficial to clarify this matter. Other variables that could affect pigment accumulation, such as fish size, types of color, and duration of feeding with pigment sources, also need to be investigated (Kop and Durmaz, 2008).

In conclusion, this study demonstrated that while the inclusion of *Schizochytrium* sp. as a feed supplement did not produce a statistically significant difference in skin coloration, it did result in improved growth performance of Jack Dempsey. Therefore, 1% dietary *Schizochytrium* sp. is advantageous for enhancing developmental performance, highlighting its potential as a beneficial additive in the culture of this chiclid species.

Declarations

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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